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Twentieth day of October 2000

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AUSTRALIA

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**ORIGINAL**

**PROVISIONAL SPECIFICATION**

Title:       ANIMAL CARCASE ANALYSIS

Applicant:   MEAT & LIVESTOCK AUSTRALIA LIMITED

The invention is described in the following statement:

## ANIMAL CARCASE ANALYSIS

This invention relates to methods and apparatus for analysing animal carcasses, particularly for ovine carcase analyses.

In the meat industry, specialist trained and skilled operators are employed, in  
5 abattoirs for example, in order to inspect each animal carcase and to provide estimates or gradings of various parameters, such as the predicted saleable meat yield of each carcase. Such predictions of meat yield and gradings are very important for fixing a fair value for the carcase and for determining uses to which the carcase and meat cuts will be destined. Obviously it is very important for the meat industry generally including producers, processors  
10 and consumers that such operators are consistent both within a particular abattoir or processing facility and between different facilities at different place and different times.

In the case of ovine carcasses, particularly sheep carcasses, the analyses commonly used include both quantitative and qualitative measurements or assessments such as dimensional measurements, yield, particularly "lean meat yield", and fat depths.

15 There have been proposed and developed automated systems for image capture and colour analysis for automating beef carcase yield predictions or gradings, or at least for providing some objective replacement or supplement to human operators. However, such automated analysis and yield predicting systems for beef have not been applicable to sheep carcasses both in their physical construction and arrangement, and also in the analyses  
20 performed and data output.

It is an object of the present invention to provide a method and apparatus for analysis of animal carcasses, particularly ovine animal carcasses, so as to automatically derive quantitative and/or qualitative descriptors or characteristics of the carcasses.

According to the present invention there is provided a process for analysing an animal carcass which includes the steps of:

providing an image capture means for capturing image data of a carcass,

presenting an animal carcass to the image capture means, the carcass being positioned

5 with the dorsal view of the carcass presented directly to the image capture means,

~~capturing image data for the dorsal view of the carcass by the image capture means,~~

processing the image data so as to automatically identify predetermined anatomical points of the carcass,

deriving dimensional measurements for the carcass by using the anatomical points

10 identified, and

deriving at least one characterising parameter related to fatness of the carcass by processing colour data included in the captured image data in conjunction with derived dimensional measurements, the colour data processed being the colour data for a predetermined selected surface area of the carcass known or determined to have a significant

15 correlation to the fatness related parameter.

It will be convenient to describe the process and apparatus in conjunction with each other. In particular, the apparatus will include suitable means for carrying out each of the steps or operations of the processes described.

Also it will be convenient to describe the invention in relation to analysis of a sheep  
20 carcass but it is to be understood that other animal carcasses can be used with the present invention, particularly ovine carcasses including, for example, goat carcasses. The particular sheep carcass system developed and to be described herein can be generally similar to systems developed and published for analysing beef carcasses, both in terms of equipment and software. Therefore reference may be made to such known systems for general features of

the sheep carcase system. For example, patent specification WO 91/14180 describes and illustrates a beef carcase analysis system providing principal components and systems required for an automated analysis system.

As sheep carcasses are typically less than half the length of beef carcasses, however, the  
5 appropriate mechanical components, which generally means anything associated with the carcase imaging station can be scaled down. Individual components such as the camera and a camera enclosure preferably providing both physical protection and a controlled environment for the camera can be substantially the same as in the beef carcase systems.

With regard to lighting of the sheep carcasses as they are presented to the image  
10 capture means at the image capture station, it may be satisfactory to provide a single light source, e.g. adjacent to the camera, to illuminate each sheep carcase presented for image capture. A single light source may be suitable since wider or more uniform illumination may not be necessary to identify the anatomical points and since colour data used in the carcase analysis operation preferably relates to selected areas relatively close to the spine so that  
15 illumination from a single light source adjacent the camera may provide sufficient illumination for such areas. However it is also possible to use distributed lighting to give a flatter more uniform light distribution.

Unlike beef carcasses which are viewed as split sides with the lateral aspect presented to the camera, sheep carcasses as mentioned earlier are imaged unsplit according to the present  
20 invention and are presented with the dorsal view, i.e. the back of the carcase, presented directly to the camera.

The analysis operations for sheep carcasses are completely different to those for beef carcasses, resulting in a completely different set of carcase measurements and descriptors and,

of course, the derived outputs from the system are completely different and are appropriate to the description of sheep carcasses.

The image capture station is designed to provide an environment to enable accurate, repeatable positioning, illumination and image capture of the sheep carcasses. It is designed  
5 so that carcasses moving on the normal abattoir carcase transport equipment progress unimpeded through an enclosure or booth and the images are automatically acquired. The carcase transport equipment preferably includes alignment devices operative to ensure the sheep carcasses are positioned with the dorsal view presented directly at the camera. The enclosure also includes sensors to detect the presence of the carcasses and control image  
10 capture.

The booth preferably includes its own lighting system to control the illumination of the carcase which the booth excludes thereby preventing all external lighting from affecting the carcase. The lighting arrangement may use light source(s) positioned adjacent or distributed around the camera to illuminate the regions of the carcase which are useful for indicating  
15 carcase fatness and to help enhance the discrimination of fat and lean regions. Also included in the field of view are standard coloured tiles which are used to calibrate colour measurements by compensating for any changes in illumination or camera characteristics. The calibration procedures and apparatus can be substantially the same as used for beef carcase systems and, in particular, can be substantially as described in detail and illustrated in  
20 patent specification WO 98/39627.

For capturing the image data for each sheep carcase, the system preferably uses a video camera. The video camera is preferably enclosed in a temperature controlled enclosure and generates standard format video signals of the carcasses which are provided to the controlling computer system. The camera and its enclosure can be substantially the same as

used for a beef carcase system and may be for example as described in Australian patent specification No. PQ 1543, filed 9 July 1999.

The image capture system including the camera and associated computer system may include a special interface card, known as a "frame grabber" to convert the camera video signals into a digital format. The image data will therefore comprise positional and colour data for each of an array of pixels representing the imaged area. Once in a digital format, the sheep analysis software running on the computer system can process the image to detect features and make quantitative measurements.

The quantitative measurements can be generally grouped into two categories:

- 10 (a) dimensional measurements, e.g. lengths, areas (including lengths and/or areas of the entire carcase or of particular components of the carcase such as the legs), ratios, angles, etc.,
- (b) colour measurements - for example each part of the captured image may be converted into three values, i.e. the RGB values representing the intensity of red, green and blue light coming from each respective part of the carcase. The absolute and relative values of these RGB numbers give a quantitative representation of the colour of the parts of the carcase. If desired, as described in Australian patent specification No. PQ 1544 filed 9 July 1999, the RGB values may be processed to provide intensity normalised colour values, i.e. colour values substantially independent of light intensity, so that subsequent analyses using these intensity normalised colour values are not subject to unwanted variations and inaccuracies due to differing light intensities of the illuminating light source(s).

The computer system would in practice also provide an operator interface for the overall system to enable control, configuration and display of results to an operator. Operator input can be via conventional peripheral devices such as via a computer mouse, keyboard, scanner, or via electronic links to other abattoir computer systems.

5 To describe and illustrate the analysis procedures reference will be made to the accompanying drawings in which:

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Figure 1 shows a captured image of a sheep carcase suspended by the hind legs, e.g. from an overhead rail in a conventional transport system of an abattoir, the carcase having been presented to the camera with the dorsal view directly facing the camera.

10 Figure 2 is a depiction of the image of Figure 1 having been analysed to identify and trace the carcase outline, particular anatomical points, and some derived dimensions, and

Figure 3 is a similar view showing predetermined areas of the carcase identified for colour based analyses.

As shown in the drawing, the captured image will include the image of the carcase  
15 against a background. The background may comprise the image of a background panel such as a non-reflective black panel located behind the carcase in the image capture booth. The illuminated carcase overlying the black background will enable ready processing of the image data to identify the outline of the carcase image, e.g. by scanning inwardly from the edges through pixels representing the background and identifying the boundary by the abrupt  
20 change in colour and/or light intensity.

It may be possible for all dimensional measurements to be used in the system of the present invention to be measurements relating to the outline, i.e. with no features internal to this outline being located, identified and measured. However, if desired, the system may be programmed and operated to analyse captured image data in the area of the rump of the

animal so as to identify the tail. As seen in the drawings, the lateral edges of the tail are delineated in the captured image by generally linear darker areas extending lengthwise along each side of the tail so that these linear darker areas can be identified by the analysis algorithms and hence the width of the tail can be determined for use in yield prediction as  
5 mentioned later.

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The main aims of the dimensional analysis are to find shape descriptors related to conformation/muscle score and also to locate features of the carcass to enable derivation of the positions for colour measurements and analysis.

Figure 2 shows the results from locating the carcass outline and the overlaid lines  
10 illustrate basic dimensional measurements. All measurements are made with relation to detected "anatomical points". These are points on the outline which are readily detected by features on the outline (e.g. sharp corners) and which are associated with particular parts of the anatomy. Examples are shown in Figure 2 as the head point, "elbows", hips, leg outer points, and the groin point. As well as simple linear distances as shown by the lines in Figure  
15 2, other measurements made may include: measurements of areas enclosed by the outline and various distance measurement lines; widths and areas on the hind legs; and angles between distance measurement lines, e.g. the groin angle between the lines from the groin to the hind legs. Another measurement mentioned earlier is the width of the tail.

The system may be calibrated so that dimensional movements or distances in the image  
20 can be converted to true distances/areas on the carcass by taking into account perspective or foreshortening effects of the dorsal view used. These and other dimensional measurements can be mathematically related to carcass descriptions provided by expert graders and also other quantitative measurements e.g. lean meat yield and fat depths, so that the measurements can be used to predict these other carcass descriptors. Purely dimensional

descriptors formerly provided by expert graders can be readily calculated from the dimensional data derived from the image analysis by relatively simple geometrical formulae or transformations. However, in deriving descriptors of the carcase such as lean meat yield, characteristics of the carcase in addition to purely dimensional characteristics are relevant and statistical methodologies can be used to derive predictive equations utilising both dimensional data as well as colour related data shown to have good predictive relationships or correlations with the descriptor being derived. An example of a purely dimensional characteristic having been determined to have good predictive correlations with yield is the width or thickness of the tail. Hence a derived measure of the width of the tail can be incorporated in a yield predictive equation.

With regard to utilising colour information in the captured image data to derive descriptors of the sheep carcase, the simplest method of extracting colour information from the carcase image is to measure the average RGB values with a defined region. Figure 3 shows rectangular areas superimposed on the carcase image. These rectangles have been positioned relative to the anatomical features found in the dimensional analysis (Figure 2) and are designed to coincide with areas that carcase grading experts use for evaluating carcase fatness. As illustrated, these areas can be in respective pairs located symmetrically on opposite sides of the spine - enabling averaging of colour values for each laterally spaced pair, or possibly alarm or error signal generation if the average colour values for the two members of any pair vary significantly from each other, enabling manual intervention to identify the cause and correct for possible misleading output descriptors.

Relationships have been found by statistical analyses, e.g. multiple regression analyses, to provide correlations between average RGB values and carcase fatness. Alternative

methods of using the RGB values to predict fatness may also be developed, e.g. analysing the rate of change of RGB values in a line profile across the carcass.

By discovering such relationships and providing the correlations to develop predictive equations, the present invention can provide a carcass analysis process and apparatus which automatically determines and outputs descriptors of the carcass, useful for example for grading and valuing the carcasses. As mentioned earlier, dimensional descriptors are relatively easily derived and output once the outline and key anatomical points have been determined from the captured carcass images. Other carcass descriptors such as lean meat yield and fat thickness are correlated not only to dimensional characteristics but also to colour characteristics and therefore the predictive equations for such descriptors can be derived by statistical techniques using both dimensional and colour related parameters in the equations.

It will be seen from the preceding description that the present invention provides a useful process and apparatus for animal carcass analysis, particularly for ovine animal carcass analysis enabling at least partially automated analysis and output of useful carcass descriptors.

It is to be understood that various alterations, modifications and/or additions may be made to the features of the possible and preferred embodiment(s) of the invention as herein described without departing from the spirit and scope of the invention.

Dated this 15th day of September 1999

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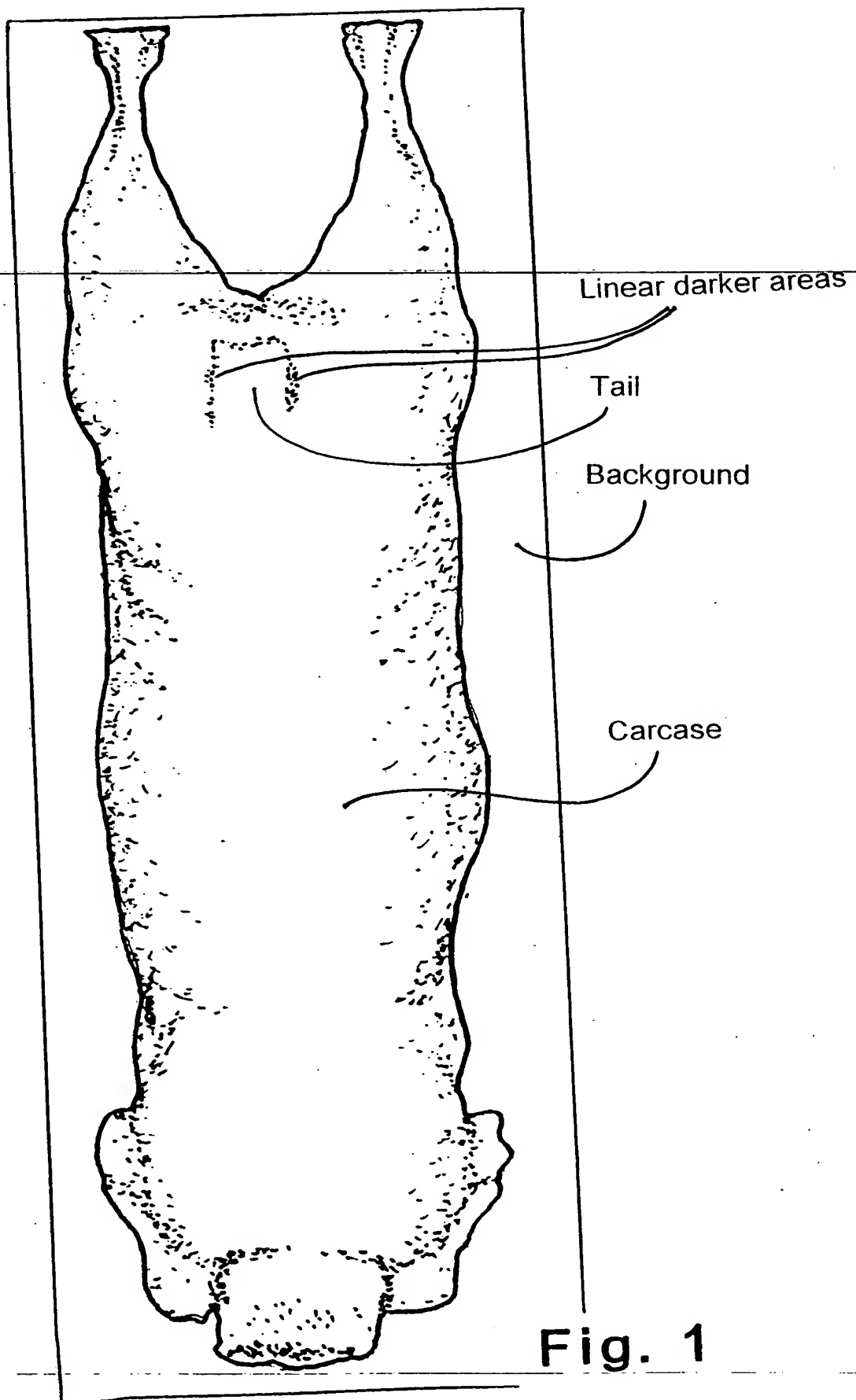
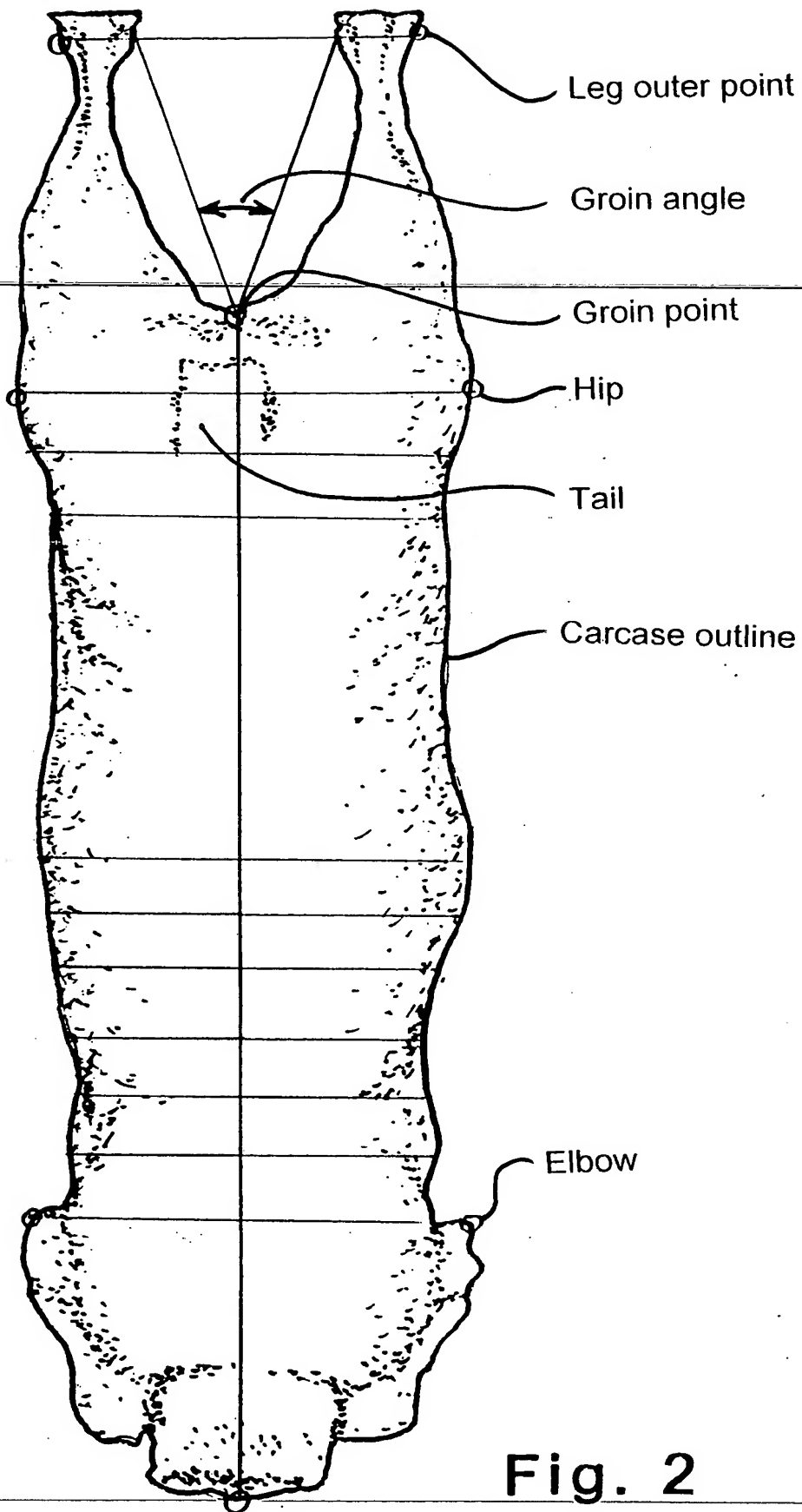
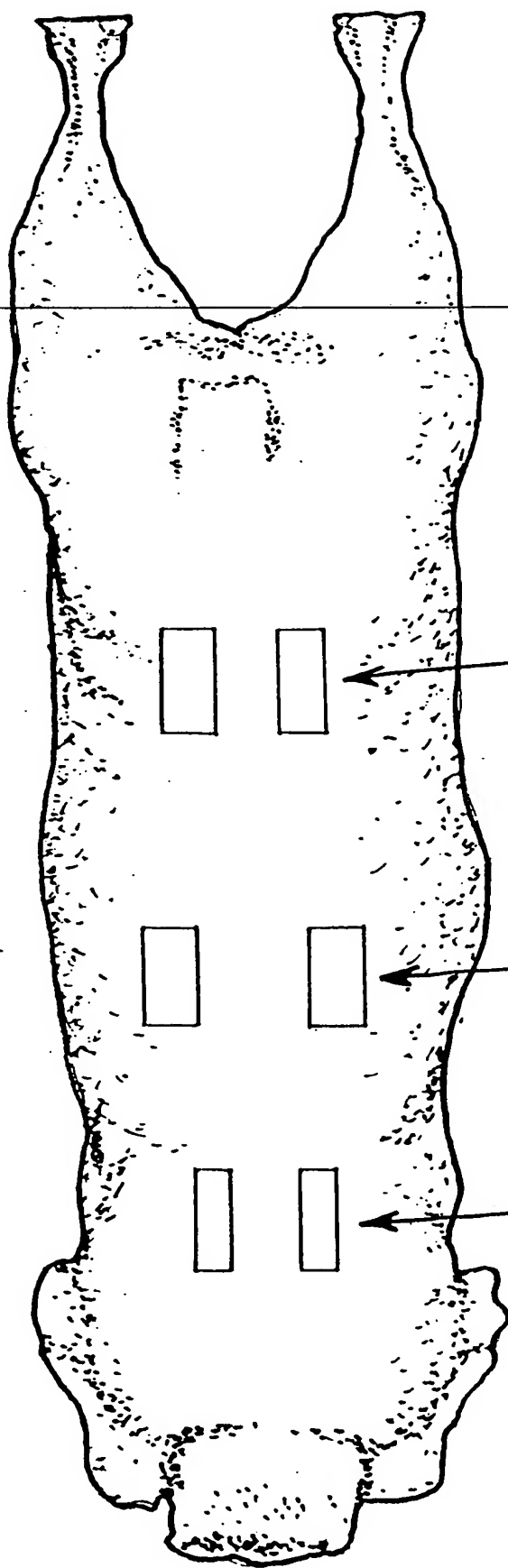


Fig. 1



**Fig. 2**



Defined  
Chump  
Region

Defined  
Loin  
Region

Defined  
Shoulder  
Region

Fig. 3

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